CLAIMS

What is claimed is:

1. A method for deriving a near-optimal fuzzy automaton for a given separation problem, comprising the steps of:

(a) forming a first generation population of fuzzy automata, where the first generation population of fuzzy automata having a plurality of fuzzy automata;

(b) performing a mutation operation on each fuzzy automata in the first generation population of fuzzy automata;

(c) reproducing the first generation population of fuzzy automata using a survival of the fittest operation; and

(d) applying a cross-over operator to the reproduced first generation population of fuzzy automata, thereby yielding a next-generation population of fuzzy automata.

2. The method of Claim 1 wherein the step of forming a first generation population further comprises the steps of providing an input set of fuzzy automata, and randomly selecting a subset of fuzzy automata from the input set of fuzzy automata.

3. The method of Claim 1 wherein the step of forming a first generation population further comprises the step of defining each of the fuzzy automata in the first generation population as one or more matrices each having a plurality of data

values, and representing in chromosome form each of the data values in at least one the matrices in each of the fuzzy automata.

4. The method of Claim 3 wherein the step of representing in chromosome form further comprises converting each of the data values to a binary word.

5. The method of Claim 1 wherein the step of performing a mutation operation further comprises randomly flipping at least one bit in each of the fuzzy automata, where the data values for each of the fuzzy automata are represented as a binary word.

6. The method of Claim 1 wherein the step of reproducing the first generation population further comprises the steps of:

evaluating the fitness of each fuzzy automaton in the first generation population of fuzzy automata;

ranking the fuzzy automata in the first generation population of fuzzy automata according to the fitness of each fuzzy automaton; and

reproducing at least one of the fuzzy automata in accordance with a reproduction rule.

7. The method of Claim 6 wherein the step of evaluating the fitness further comprises the steps of:

identifying a set of input signals;

evaluating each of the fuzzy automata in the first generation population of fuzzy automata based on the set of input signals, thereby yielding a confusion matrix for each fuzzy automaton; and

determining a diagonal dominance indicator for each confusion matrix.

8. The method of Claim 7 wherein the step of determining a diagonal dominance indicator further comprises the step of computing the diagonal dominance indicator, D, in accordance with

$$D = (C_{\text{smallest on-diagonal}} - C_{\text{largest off-diagonal}}) / ((C_{\text{smallest on-diagonal}} + C_{\text{largest off-diagonal}})/2)$$

9. The method of Claim 6 wherein the step of ranking the fuzzy automata further comprises ranking the fuzzy automata from most fit to least fit based on the diagonal dominance indicator.

10. The method of Claim 6 wherein the step of reproducing at least one of the fuzzy automata further comprises defining the reproduction rule such that the two highest ranked fuzzy automata in the first generation population of fuzzy automata are duplicated and the lowest two ranked fuzzy automata in the first generation population of fuzzy automata are eliminated.

11. The method of Claim 1 wherein the step of applying a crossover operator further comprises the steps of:

randomly identifying at least two of the fuzzy automata in the first generation population of fuzzy automata, where each of the two fuzzy automata is defined by one or more matrices each having a plurality of data values;

representing in chromosome form each of the data values in at least one of the matrices in each of the two fuzzy automata; and

applying a crossover operator to at least one matrix in each of the two fuzzy automata, where the crossover operator determines the alleles of crossover between the two fuzzy automata, thereby yielding two next-generation fuzzy automata.

12. The method of Claim 11 wherein the step of representing in chromosome form further comprises converting each of the data values to a binary word.

13. The method of Claim 11 wherein the step of applying a crossover operator further comprises a transform matrix having the same dimensions as at least one matrix in each of the two fuzzy automata, where the entries in the transform matrix are numbers that determine the alleles of crossover in the corresponding data values of at least one matrix in each of the two fuzzy automata.

14. The method of Claim 11 wherein the step of randomly identifying at least two of the fuzzy automata further comprises defining each of the at least two fuzzy automata as a quintuple (U^S, U^R, U^{E0}, A*, B*), where U^S is a matrix of fuzzy state

transitions, U^R is a matrix of fuzzy output transitions, U^{E0} is a vector of fuzzy state memberships, A* is a space of input vectors, and B* is a space of output vectors.

15. The method of Claim 14 wherein the step of applying a crossover operator is applicable to U^S, U^R, U^{E0} of at least two fuzzy automata.

16. The method of Claim 1 further comprising the steps of:

evaluating the performance of each fuzzy automaton in the next generation of fuzzy automata in relation to the given separation problem; and

repeating steps (b) thru (d) until at least one fuzzy automaton from the next-generation of fuzzy automata achieves a satisfactory performance level in relation to the given separation problem.

17. The method of Claim 16 wherein the step of repeating steps (b) thru (d) further comprises using the next-generation population of fuzzy automata as input to the mutation operation.

18. A method for generating a next generation of fuzzy automata, comprising the steps of:

providing a first and a second input fuzzy automaton, where each fuzzy automaton is defined by one or more matrices each having a plurality of data values;

representing in chromosome form at least one of the matrices in each of the first and second input fuzzy automata; and

applying a crossover operator to at least one matrix in each of the first and second input fuzzy automata, where the crossover operator determines the alleles of crossover between the first and second input fuzzy automata, thereby yielding two next-generation fuzzy automata.

19. The method of Claim 18 wherein the step of representing in chromosome form further comprises converting each of the data values to a binary word.

20. The method of Claim 18 wherein the step of applying a crossover operator further comprises a transform matrix having the same dimensions as at least one matrix in each of the two fuzzy automata, where the entries in the transform matrix are numbers that determine the alleles of crossover in the corresponding data values of the at least one matrix in each of the two fuzzy automata.

21. The method of Claim 18 wherein the step of providing a first and a second input fuzzy automaton further comprises defining each of the first and second input fuzzy automata as a quintuple (U^S, U^R, U^{E0}, A*, B*), where U^S is a matrix of fuzzy state transitions, U^R is a matrix of fuzzy output transitions, U^{E0} is a vector of fuzzy state memberships, A* is a space of input vectors, and B* is a space of output vectors, such that the crossover operator is applicable to U^S, U^R, U^{E0} of the first and second input fuzzy automata.

22. A method for evaluating the performance of a fuzzy automata, comprising the steps of:

identifying a set of input signals;

evaluating the set of input signals using the fuzzy automata, thereby yielding a confusion matrix for each fuzzy automata; and

determining a diagonal dominance indicator for each confusion matrix.

23. The method of Claim 22 wherein the step of determining a diagonal dominance indicator further comprises the step of computing the diagonal dominance indicator, D, in accordance with

$$D = (C_{\text{smallest on-diagonal}} - C_{\text{largest off-diagonal}}) / ((C_{\text{smallest on-diagonal}} + C_{\text{largest off-diagonal}})/2)$$